

Activity Matrix

	Science as Inquiry	Position and Motion of Objects	Physical Science	Properties of Objects and Materials	Unifying Concepts and Processes	Evidence, Models, and Explanation	Science and Technology	Science in Social and Personal Perspectives	History and Nature of Science
Air Engines									
Dunked Napkin									
Paper Bag Mask									
Wind InYour Socks									
Bag Balloons									
Sled Kite									
Right Flight									
Delta Wing Glider									
Rotor Motor									
Making Time Fly									
Where is North?									
Let's Build aTable Top Airport									
Plan to FlyThere									

Science Standards

Activity Matrix

	Problem Solving	Communication	Reasoning	Connections	Measurement	Verifying and Interpreting Results	Estimation	Prediction	Graphs
Air Engines									
Dunked Napkin									
Paper Bag Mask									
Wind inYour Socks									
Bag Balloons									
Sled Kite									
Right Flight									
Delta Wing Glider									
Rotor Motor									
Making Time Fly									
Where is North?									
Let's Build aTable Top Airport									
Plan to FlyThere									

Mathematics Standards

Activity Matrix

	Observing	Communication	Measuring	Collecting Data	Predicting	Making Graphics	Investigating	Interpreting Data	Controlling Variables	Making Models
Air Engines	●				●	●	●			
Dunked Napkin	●						●			
Paper Bag Mask			●		●			●		●
Wind in Your Socks	●		●							●
Bag Balloons	●		●							●
Sled Kite	●		●		●					
Right Flight	●		●	●	●			●	●	●
Delta Wing Glider						●	●			●
Rotor Motor	●								●	●
Making Time Fly		●		●		●				
Where is North?	●							●		●
Let's Build a Table Top Airport		●	●			●				●
Plan to Fly There		●	●				●			

Science Process Skills

The NASA Aeronautics and Space Transportation Technology Enterprise

NASA's Aeronautics and Space Transportation Technology Enterprise is focused on long-term, high risk, high-payoff research and technology. Working closely with our partners in industry, government, and academia, we have set bold goals to sustain future U.S. leadership in civil aeronautics and space. We group our goals into Three Pillars: "Global Civil Aviation," "Revolutionary Technology Leaps," and "Access to Space."

Our ten goals focus on enabling technologies for a safer, cleaner, more affordable global aviation system; sustainable growth in aviation products and services; and affordable access to space. Achieving our goals—which are stated in terms of the final outcome—will have profound social, economic, and political impact on our Nation.

Aviation has always been an exciting and risk-taking venture. With a strong partnership among industry, government, and academia, our history of innovation and technological breakthroughs will continue. As we enter the 21st century, we in the aerospace community are excited about the future, for both its challenges and its opportunities.

Global Civil Aviation

Enabling U.S. leadership in the global aircraft market through safer, cleaner, quieter, and more affordable air travel.

Safety:

- Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 20 years.

Environmental Compatibility:

- Reduce emissions of future aircraft by a factor of three within 10 years, and by a factor of five within 20 years.

Affordable Air Travel:

- While maintaining safety, triple the aviation system throughput, in all weather conditions, within 10 years.

- Reduce the cost of air travel by 25% within 10 years, and by 50% within 20 years.

Revolutionary Technology Leaps

Enabling technology goals to revolutionize air travel and the way in which aircraft are designed, built, and operated.

High-Speed Travel:

- Reduce the travel time to the Far East and Europe by 50% within 20 years, and do so at today's subsonic ticket prices.

General Aviation Revitalization:

- Invigorate the general aviation industry, delivering 10,000 aircraft annually within 10 years, and 20,000 annually within 20 years.

Next-Generation Design Tools and Experimental Aircraft:

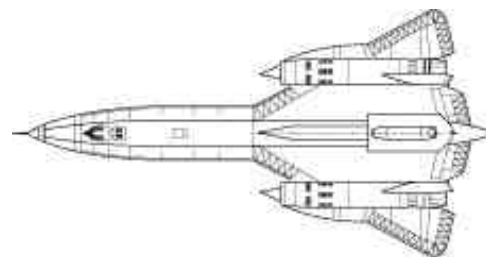
- Provide next-generation design tools and experimental aircraft to increase design confidence, and cut the design cycle time for aircraft in half.

Access to Space

Enabling technology goals to unleash the commercial potential of space and greatly expand space research and exploration.

Revolutionize America's Space Launch Capabilities:

- Reduce the payload and cost of low-Earth orbit by an order of magnitude, from \$10,000 to \$1,000 per pound, with 10 years.
- Reduce the payload cost to low-Earth orbit by an additional order of magnitude, from thousands to hundreds of dollars per pound, by the year 2020.



NASA SR-71 with Linear Aerospike
Rocket Engine Experiment
1998

Aeronautics

Background for Educators

“Birds fly, so why can’t I?” That question was probably first asked by cave dwellers watching a bird swoop through the air. Perhaps even then, people understood the advantages of human flight. The desire to defy gravity and experience the freedom of flight compelled early attempts to unravel the mysterious technique the birds had mastered proficiently.

Piloted flight and the mobility it offered to humankind would have to wait many centuries. The more immediate goal of the cave dwellers was survival. The discovery of fire by early inhabitants helped assure a permanent place on Earth for descendants. While a small spark eventually produced the light and heat of fire, the spark for flight was imagination. Ironically, the discovery of fire would play a major role in our first flight. Fire and flight forever changed the way we lived.

The writings and voices of past civilizations provide a record of an historical obsession with flight. The aerial dreams of early writers are revealed in Roman and Greek mythology. The mythical father and son team of Daedalus and Icarus used artificial wings of wax and bird feathers to escape from Crete. In Greek mythology, Pegasus was a winged horse. Some writings contributed significantly to the emerging science. From the early 1480’s until his death in 1519, the Florentine artist, engineer, and scientist, Leonardo da Vinci, dreamed of flight and produced the first drawings for an airplane, helicopter, *ornithopter*, and parachute.

In the early 17th century, serious aeronautical research was conducted by so-called “birdmen” and “wing flappers.” These early experimenters were erroneously convinced that wings strapped to a human body and muscle power were the answer to flight. The experiments made scant contributions to aeronautical knowledge or progress, and universally ended with the pain of broken bones or the solitude of death. By the mid-17th century, serious-minded experimenters had correctly decided that humans would never

duplicate bird flight. They turned their attention to finding a device that would lift them into the air.

Two French paper makers, Joseph and Etienne Montgolfier, noting the way smoke from a fire lifted pieces of charred paper into the air, began experimenting with paper bags. They held paper bags, open end downward, over a fire for a while and then released them. The smoke-filled bags promptly ascended upward. Smoke, the brothers deduced, created a lifting force for would-be flyers. Scientists would later explain that when air is heated, it becomes less dense, thus creating a buoyant or lifting force in the surrounding cool air.

On September 19, 1783, a sheep, a rooster, and a duck were suspended in a basket beneath a Montgolfier balloon. The cloth and paper balloon was 17 meters high, and 12 meters in diameter. A fire was lit, and minutes later the balloon was filled with hot air; it rose majestically to a height of more than 500 meters. The farm animals survived the ordeal and became the first living creatures carried aloft in a human-made device. The dream of flight was now the reality of flight. Two months later on November 21, 1793, two volunteers stepped into the basket and flew for eight kilometers over Paris, thereby becoming the world’s first aeronauts. Flying became practical in lighter-than-air devices, and balloon mania set in.

Throughout the 19th century, *aeronauts* experimented with hydrogen gas-filled balloons and struggled to devise a method to control them. After another century of experimenting, the balloon had become elongated and fitted with propulsion and steering gear. Ballooning had become a fashionable sport for the rich, a platform for daring circus acts, and provided valuable observation posts for the military. Yet none of this was flying the way birds fly – fast, exciting, darting, diving, and soaring with no more than an effortless flick of wings. To escape the limitations of a floating craft, early researchers began the search for another, more exciting form of lift.

A small but dedicated handful of pioneers were convinced that the future of human flight depended more on wings and less on smoke

and hot air. One of these early pioneers had an intense interest in the flight of birds and became obsessed with ways its principles might be adapted by humans. As early as 1796, Englishman George Cayley conducted basic research on *aerodynamics* by attaching bird feathers to a rotating shaft, thereby building and flying a model helicopter. In 1804, he built and flew the world's first fixed-wing flyable model glider. This pioneering model used a paper kite wing mounted on a slender wooden pole. A tail was supported at the rear of the pole providing horizontal and vertical control. It was the first true airplane-like device in history.

In 1849, after years of extensive and persistent research, Cayley constructed his "boy glider." This full-sized heavier-than-air craft lifted a 10 year old boy a few meters off the ground during two test runs. Four years later, Sir George Cayley persuaded his faithful coachman to climb aboard another glider and make the world's first piloted flight in a fixed-wing glider.

In Germany, Otto Lilienthal believed that arched or curved wings held the secret to the art of flight. In his Berlin workshop, Lilienthal built test equipment to measure the amount of lift that various shapes of wings produced. His work clearly demonstrated the superior lifting quality of the curved wing. By 1894, Lilienthal's unpowered flying machines were achieving spectacular glides of over 300 meters in distance. Lilienthal built a 2 1/2 horsepower carbonic acid gas engine weighing 90 pounds. He was ready to begin powered glider experiments. Unfortunately, Lilienthal was killed in an 1896 glider mishap before he could test his power-driven airplane.

Otto Lilienthal left behind an inspiration and a warning. If his life's work proved that we could fly, then his death was a somber warning. Humans would have to master the aerodynamics of wings before flight like the birds could be accomplished with confidence and safety. His extensive research and experiments in aviation brought the world closer to realizing the age-old dream of human flight.

Lilienthal's work was carried forward by one of his students, a Scotsman named Percy Pilcher.

Like Lilienthal, Pilcher built his own four-horsepower engine in hopes of achieving powered flight. Ironically, before he could conduct any experiments with powered flight, Pilcher was killed in a glider accident during 1899.

As the 19th century drew to a close, aviation pioneers continued to probe the mystery surrounding mechanical flight. Octave Chanute, Samuel Langley, and others experimented to produce further understanding of aeronautical principles and knowledge, yet controlled, powered flight was not realized. In 1900, the world waited for a lightweight power source and a method to control flight.

On May 30, 1899 Wilbur Wright wrote to the Smithsonian Institution in Washington, D.C. requesting information about published materials on aeronautics. By early summer of that year, Wilbur and his brother Orville had read everything they could find on the subject. The Wright brothers began a systematic study of the problem of flight by conducting research on the methods tried by previous experimenters. They conducted hundreds of wind tunnel experiments, engine and propeller tests, and glider flights to gain the knowledge and skill needed to fly.

On December 17, 1903, four years after beginning their research, the world was forever changed. A fragile cloth and wood airplane rose into the air from a windswept beach at Kitty Hawk, North Carolina, and flew a distance of 36 meters. The brothers provided the world with a powered flying machine controlled by the person it carried aloft. Ingenuity, persistence, and inventiveness had finally paid a big dividend—the Wright Flyer was successful. This 12-second event marked the beginning of tangible progress in the development of humancarrying, power-driven airplanes.

By 1905, an improved Wright Flyer could fly more than 32 kilometers and stay aloft almost 40 minutes. Five years later, the first international air meet in the United States was held in Los Angeles, California. Glenn Curtiss set a new world's speed record of 88 kilometers per hour and Frenchman Louis Paulhan set an altitude record of 1250 meters. At the outbreak of World

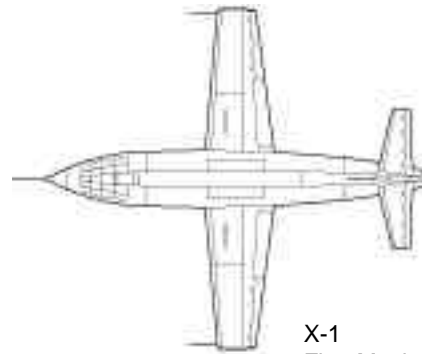
War I, the airplane could fly at speeds of over 200 kilometers per hour and reach altitudes of 7500 meters.

The Congress of the United States recognized that a new era in transportation was beginning and the changes would have significant impact on human interchange, commerce, foreign relations, and military strategy. Flight research in the United States got a significant boost in 1915. The National Advisory Committee for Aeronautics (NACA) was formed by the United States Congress “to supervise and direct the scientific study of the problems of flight, with a view to their practical solutions.”

By the 1930's, NACA wind tunnels and flight test investigations led to improvements in aircraft performance and safety. Research produced new *airfoil* or wing shapes and propeller designs that increased the safety and efficiency of airplanes. New engine cowlings and aerodynamic streamlining reduced drag and increased aircraft speed.

Today NACA's successor, the National Aeronautics and Space Administration (NASA), has a much broader mission. As its name implies, NASA continues research to keep aviation on the cutting edge of technology for airfoils, materials, construction techniques, engines, propellers, air traffic control, agriculture development, electronics, efficiency, and safety. NASA is striving to make airplanes ecologically safe by lessening the sonic boom for aircraft traveling at *supersonic* speeds and developing propulsion systems that use pollutant-free fuel.

On August 17, 1978 near Paris, France, a hot air balloon descended from the sky and landed in cornfield. Thousands of onlookers watched and cheered as the three crew members stepped down from the Double Eagle II. They had just completed the first nonstop crossing of the Atlantic Ocean in a balloon. Almost two hundred years earlier in 1783, Parisians cheered the Montgolfier brothers as they launched the first hot air balloon. The time span between the two events is filled with flight milestones that have taken humankind from the dream of flight to landing on the moon.



X-1
First Mach 1 Flight
1946-1951

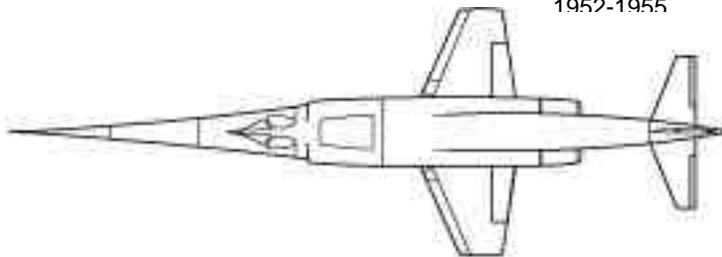


D-558-1
Transonic Jet
1947-1953

Exploring Supersonic Flight



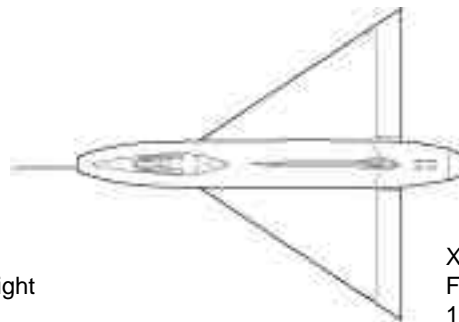
X-4
Semitailless Jet
1948-1953



X-3
Titanium Structures
1952-1955



D-558-II
First Mach 2 Flight
1948-1956



XF-92A
First Delta Wing Jet
1948-1953



X-2
First Mach 3 Flight
1955-1956

The NACA Experimental Research Aircraft Program which began in the 1940's took human flight to previously unexplored speeds and altitude



X-4
First Variable-Sweep Wing
1951-1955